# Smallholder Farmers' Adoption of Climate-Smart Agricultural Practices in Mwachisompola Agricultural Camp of Chibombo District, Zambia.

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## ABSTRACT

This purpose of the study was to evaluate the climate-smart agriculture practices in enhancing resilience among small holder farmers in Mwachisompola agriculture camp in Chibombo district. The study determined the extent to which smallholder farmers in Mwachisompola Agricultural camp have adopted climate-smart agricultural practices. The study employed the mixed research approach to collect and analyse the data. The study employed the embedded research design. The target populations of the study were small scale farmers, Agriculture Camp Officer, Agriculture Block Officer of Mwachisompola Agricultural Camp, Senior Agriculture Officer and District Agriculture Officer of Chibombo district. The sample size was two hundred fifty four (254). These included one (1) Agriculture Camp Officer, one (1) Block Agricultural Officer, one (1) District Agriculture Officer and One (1) Senior Agriculture Officer and two hundred fifty (250) small scale farmers from the selected Mwachisompola agriculture camp of Chibombo district. The research instruments used collect data were questionnaire and the interview guide. Thematic analysis was used to analyse qualitative data while descriptive statistical analysis with the use of the mean and standard deviation was used to analyse the quantitative data. The study found that the adoption of (CSA) practices among smallholder farmers was moderate. The study recommends that the Government of the Republic of Zambia, through the Ministry of Agriculture should strengthen and expand extension services, implement targeted subsidies and financing programs, invest in rural infrastructure and climate information systems.

**Keywords:** climate, smart, agriculture practices, enhancing, resilience, small holder farmer.

## INTRODUCTION

Climate-smart agriculture (CSA) practices offer opportunities to mitigate these impacts and enhance resilience. Moreover, Zambia has made strides in promoting CSA, with support from various stakeholders including the government, international development agencies, and civil society. According to Zulu et al. (2021), these practices have gained traction among farmers in some regions, with demonstrable improvements in productivity, soil quality, and resilience to climate shocks. Furthermore, the FAO (2020) reports that CSA techniques can increase yields by up to 70% in rain-fed conditions, particularly when tailored to local agro-ecological zones. Farmers in Chibombo district exemplifies both the potential and challenges of implementing CSA. The district is primarily agrarian, with most households engaged in small-scale farming of crops such as maize, groundnuts, sweet potatoes, and vegetables. However, the district has been increasingly affected by unpredictable rainfall patterns, prolonged dry spells, and occasional flash floods leading to declining agricultural output and rising food insecurity (Mwape et al., 2023). Agriculture camps across the district, such as Mwachisompola, Katuba, and Keembe, have witnessed significant variability in harvests due to these environmental changes.

Despite the interventions by the Ministry of Agriculture and non-governmental organizations to introduce CSA practices in selected agriculture camps, adoption has been uneven. Some farmers have embraced practices like minimum tillage and composting, while others have been slow to adopt due to lack of knowledge, inputs, or institutional support. There is a need to assess how well CSA initiatives have been implemented and whether they are effectively enhancing resilience among the smallholder population in Chibombo district. Moreover, no comprehensive study has evaluated the implementation process, farmer perceptions, and practical challenges associated with CSA in Chibombo's local context. Understanding these dimensions is crucial for informing future interventions, scaling up successful practices, and designing targeted support programs. This study, therefore, seeks to evaluate the implementation of climate-smart agriculture in enhancing the resilience of small-scale farmers in selected agriculture camps of Chibombo District.

The rationale for this study lies in the need to understand how climate-smart agriculture (CSA) can be effectively implemented to enhance the resilience of small-scale farmers in Chibombo district, where agricultural productivity is increasingly threatened by climate change effects such as erratic rainfall, droughts and soil degradation. Most smallholder farmers in the district depend on rain-fed agriculture and lack access to adaptive technologies and resources, making them vulnerable to climate shocks. CSA offers solution through practices like conservation farming, crop diversification, and the use of drought-tolerant seeds, which aim to improve productivity, strengthen adaptive capacity and ensure environmental sustainability. This study is therefore aim to evaluate how CSA is being applied in selected agricultural camps, its effectiveness in building resilience among farmers.

## Statement of the Problem

In Chibombo district, climate change continues to significantly threaten small-scale farming a primary livelihood for the majority of the population. Farmers in this region have increasingly experienced delayed rainfall, shortened growing seasons, soil erosion, and droughts, leading to frequent crop failure and declining productivity (Mwape et al., 2023). These challenges have led to heightened food insecurity, reduced incomes, and the deepening of rural poverty. While CSA has been introduced as a viable strategy to combat these effects, its implementation has not been systematically evaluated at the local level. Ideally, the introduction of CSA in agriculture camps should promote sustainable productivity, improve resource-use efficiency, and increase farmers' ability to adapt to climate shocks. However, in reality, many small-scale farmers in the district continue to face persistent vulnerabilities due to limited awareness, inconsistent access to inputs and training, poor extension services, and insufficient financial support to invest in CSA technologies (Kalinda & Tembo, 2022). The lack of effective implementation frameworks, coupled with minimal monitoring and evaluation, has further limited the impact of CSA interventions.

A few notable studies have revealed that conservation agriculture and agroforestry practices have enhanced resilience among small holder farmers in sub-Sharan Africacountries have been shown to enhance resilience and improve yields in other contexts (Kumar et al., 2018). Some notable studies include A study in Malawi which found that conservation agriculture increased crop yields and reduced labor requirements (Thierfelder et al., 2017). While research in Kenya showed that agroforestry practices improved soil fertility and increased biodiversity (Kumar et al., 2018). While In Zambia, a study on climate-smart agriculture found that adoption was influenced by access to extension services and credit (Sinyolo et al., 2018).Although the success of CSA depends not only on its technical soundness but also how it is understood and accepted and adapted by the farming communities it targets. In Zambia, there is limited information on how Climate change is projected to exacerbate poverty and food insecurity in Zambia, with smallholder farmers being the most vulnerable (IPCC, 2014) Therefore to fill this information gap, and to inform the design and implementation of effective policy measures for enhancing CSA practices among small holder farmers, this study seeks to evaluate the extent to which climate-smart agriculture has been effectively implemented in selected agriculture camps of Chibombo district and how it has contributed to enhancing the resilience of small-scale farmers.

## Theoretical Framework

### Diffusion of Innovation: Rogers - 2003

Rogers' Diffusion of Innovation (DOI) Theory provides a comprehensive explanation of how new ideas and practices spread within a social system, making it an appropriate lens for examining the adoption of climate-smart agricultural practices among smallholder farmers (Rogers, 2003). According to Rogers, the diffusion

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process is influenced by specific attributes of an innovation that determine the speed and extent of its uptake. These include relative advantage, compatibility, complexity, trialability, and observability attributes that align closely with the variables emphasized in the conceptual framework for this study. Relative advantage refers to the degree to which an innovation is perceived as better than the existing practice, which is crucial in influencing farmer decisions (Rogers, 2003). In the context of climate-smart agriculture, practices that demonstrate higher yields, better soil fertility, reduced climate risks, or improved household income present clear perceived benefits, which motivate farmers to adopt them, consistent with findings in agricultural innovation adoption studies (Feder et al., 1985).

Compatibility, another key DOI attribute, relates to how well an innovation aligns with existing cultural values, farming systems, and local knowledge. Innovations that fit seamlessly within farmers’ traditional practices are more readily embraced, whereas those perceived as culturally or technically disruptive encounter greater resistance (Leeuwis & Van den Ban, 2004). Complexity, which concerns the perceived difficulty of understanding and implementing an innovation, also plays a crucial role in adoption. CSA practices that require advanced knowledge or specialized tools may be seen as complicated by smallholder farmers, discouraging uptake (Rogers, 2003). Trialability, on the other hand, reflects the extent to which farmers can experiment with an innovation before fully committing to it. Demonstration plots and pilot projects have been widely shown to reduce uncertainty and increase farmers’ confidence in adopting new agricultural technologies (Feder & Umali, 1993). Similarly, observability refers to how visible the results of an innovation are within the community. When farmers observe peers benefiting from CSA through increased yields or improved resilience the innovation becomes more socially acceptable, thereby accelerating its diffusion (Rogers, 2003).

The theory also acknowledges the influence of contextual and structural factors, referred to as innovation-decision influences, which align with the moderating variables in your conceptual framework. These include social norms, the availability of resources, access to knowledge, support from extension services, market conditions, and broader socio-cultural environments (Leeuwis & Van den Ban, 2004). Barriers such as limited training, lack of credit, inadequate agricultural inputs, and traditional beliefs can significantly reduce the likelihood of adoption, even when farmers perceive the innovation as beneficial (Feder et al., 1985). This consideration of external constraints makes DOI particularly relevant for analyzing CSA adoption, as smallholder farmers often operate under resource-limited and risk-averse conditions exacerbated by climate variability (Morton, 2007). Thus, the diffusion of innovation theory will strengthen the study by offering a coherent and empirically supported explanation of why adoption patterns differ among farmers and which specific characteristics of CSA practices influence acceptance.

## Conceptual Framework

The conceptual framework below demonstrates the relationships among the four themes in the adoption of CSA to enhance resilience and productivity. Figure 1.1 below shows the conceptual framework.

Figure 1.1: Conceptual Framework

This conceptual framework was applied to examine how factors such as perceived benefits, compatibility with existing farming practices, ease of implementation, opportunities to trial practices, and visibility of results influence farmers’ perceptions and attitudes toward adopting climate-smart agriculture (CSA) practices. Farmers’ understanding, confidence, and willingness to implement these practices mediate the relationship between these factors and outcomes, which include the level of CSA adoption, enhanced resilience to climate variability, and productivity gains such as increased crop yields and income. The framework also accounts for barriers such as limited knowledge and training, insufficient resources, and socio-cultural norms, which may moderate the adoption process. By collecting data on these variables, researchers analyzed how independent factors affect adoption outcomes, how perceptions mediate this effect, and how contextual barriers influence the overall adoption of CSA practices, providing evidence for targeted interventions and policy support.

## LITERATURE REVIEW

Junpeng Li, Wanglin Ma and Huanyu Zhu (2023) in the article A systematic literature review of factors influencing the adoption of climate-smart agricultural practices found that adoption is shaped by personal, farm-level, financial, environmental and informational factors. The study further revealed that the "penetration rate of CSA practices remains low worldwide" (Li et al., 2023). This shows that although CSA has gained recognition, practical implementation is still constrained by socio-economic barriers, institutional weaknesses, and resource limitations, which highlights the need for long-term, supportive interventions to enhance adoption. Food and Agriculture Organization (2023) in the Climate-Smart Agriculture Sourcebook found that CSA practices are designed to simultaneously increase productivity, enhance resilience to climate change, and reduce greenhouse gas emissions. The sourcebook highlighted through case illustrations that integrating CSA into policies and extension services can help address food security and climate change challenges. The findings are important because they provided a global framework and practical strategies, although the emphasis was largely conceptual, with limited empirical validation of adoption outcomes in different contexts.

Khatri-Chhetri et al. (2019) studied farmers' prioritization of climate-smart agriculture practices: Evidence from South Asia found that farmers gave higher priority to drought-tolerant seed varieties, irrigation improvements, and soil fertility management. Adoption was influenced by access to credit, information availability, and perceived profitability. The findings emphasized that adoption is highly context-specific, with wealthier farmers more capable of adopting capital-intensive practices, underscoring the importance of tailoring CSA interventions to local realities.

Manda et al. (2016) studied the determinants of adoption and impacts of sustainable agricultural practices in developing countries found that households with higher education levels, access to extension services, and participation in farmer groups were more likely to adopt multiple CSA practices. The study also showed that adoption improved household welfare through increased food security and income. The findings highlighted the dual economic and resilience benefits of CSA, but also pointed out that poorer households and women often face barriers, limiting inclusive adoption. Thorpe et al. (2022) also carried out a study on the interventions promoting resilience through climate-smart agricultural approaches found that training, farmer field schools, and demonstration plots effectively increased awareness and trialing of CSA practices. However, long-term adoption was sustained only when farmers had access to credit, input markets, and reliable supply chains. The findings showed that extension is essential but not sufficient, indicating the importance of comprehensive support systems that address both knowledge and economic incentives for adoption.

Khatri-Chhetri and Aggarwal (2022) studied the adoption and dis-adoption dynamics of CSA practices in South Asia found that while farmers initially embraced practices such as zero tillage and crop diversification, some later abandoned them due to inconsistent returns or labor constraints. The findings demonstrated that adoption is a dynamic process influenced by changing household circumstances and market conditions, emphasizing the importance of ongoing support and adaptation to ensure long-term practice retention. Dessart etal (2019) studied the behavioral factors affecting the adoption of sustainable farming practices found that adoption decisions are strongly influenced by attitudes, risk perceptions, and social norms. Farmers were more likely to adopt CSA when they perceived climate risks as severe and when peers were adopters. The findings indicated that behavioral and social influences are as critical as financial and technical enablers, pointing to the value of peer learning and behavioral interventions in scaling CSA adoption. Chandra et al. (2022) studied the adoption of climate-smart agriculture technologies in smallholder farming systems found that education, cooperative membership, and household income were positively associated with adoption of conservation agriculture, agroforestry, and water-harvesting practices. Labor availability and risk perceptions also shaped adoption decisions. The findings revealed that adoption varied within communities, with wealthier households better positioned to adopt, pointing to the need for socially inclusive approaches to CSA promotion.

Branca et al. (2021) studied the climate-smart agriculture, a synthesis of empirical evidence of adoption impacts found that CSA adoption improved yields, soil fertility, and resilience outcomes, but high upfront costs and uncertain benefits limited uptake. The study also emphasized that incentive mechanisms such as subsidies and carbon credits were necessary to accelerate adoption among resource-poor farmers. The findings demonstrated the global potential of CSA in enhancing both livelihoods and mitigation, while also underscoring the persistent financing gap that restricts broader adoption.

Mwongera et al. (2021) studied CSA practices in Kenya and Tanzania and found that small-scale farmers who adopted intercropping, agroforestry, and improved seed varieties experienced increased crop yields and reduced vulnerability to climatic shocks. The study emphasised the need for participatory approaches, especially involving women and youth, to ensure local ownership and sustainability. Farmers who were engaged in community-led CSA decision-making processes were more likely to adopt the practices effectively. The study demonstrated the value of community inclusion and tailored approaches in African CSA interventions. Dinesh et al. (2020) conducted a cross-country review of ten sub-Saharan African nations and identified widespread challenges to CSA implementation. These included limited access to climate information, weak extension systems, and lack of financing mechanisms. The study highlighted promising CSA innovations such as solar irrigation, index-based insurance and mobile-based climate advisory services, which significantly enhanced resilience in areas with proactive institutional support. The study concluded that scaling CSA requires investment in agricultural knowledge systems and partnerships between public and private stakeholders.

Shikuku et al. (2021) assessed the effectiveness of government-led CSA programs in five African countries and reported that countries with integrated CSA strategies and consistent investment in extension systems showed better implementation outcomes. For example, areas with digital platforms for disseminating weather forecasts, planting advice and CSA training have greater farmer participation. However, the study cautioned that many CSA policies remained at the pilot stage and were poorly monitored. The study emphasised the importance of national coordination and impact assessment. O’raye etal (2023) studied the adoption of climate-smart agricultural practices in sub-Saharan Africa, a review of the progress, barriers, gender differences. The study found that adoption of CSA practices across Sub-Saharan Africa is still relatively low but varies by region, with key determinants including socio-psychological traits, environmental conditions, economic resources, institutional support, and structural issues. The study also found that gender-based barriers, particularly women’s limited access to resources and decision-making, strongly affected adoption levels. These findings highlight the need for multidimensional and gender-sensitive strategies to enhance CSA uptake.

Minentle etal (2025) assessed the adoption and impact of climate-smart agricultural practices on smallholder maize farmers’ livelihoods in Sub-Saharan Africa, a systematic review. The study found that factors such as extension access, credit availability, and climate information significantly influenced adoption, while evidence on long-term livelihood impacts remained limited. The study also found that farmer organization membership enhanced adoption rates. This shows that although adoption is growing, the benefits need further longitudinal evidence to prove sustainability. Stephen et al (2025) studied the determinants of adoption and intensity of use of climate-smart agriculture practices among smallholder leafy vegetable agripreneurs in Semi-Arid Central Tanzania. The study found that secure land tenure, access to markets, and extension services strongly drove adoption, while small landholders adopted CSA more intensively to maximize scarce resources. The study also found that men were more likely to adopt costly and capital-intensive CSA practices. This illustrates how tenure security, market links, and gender roles shape adoption intensity in semi-arid areas.

Chinweuba etal (2025) carried out a study on climate smart agriculture practices: a synthesis of implementation in Nigeria. The study found that adoption of CSA in Nigeria remained relatively low due to poor awareness, lack of technical skills, and weak policies. The study also found that access to extension services, education, and farming experience were major enablers of adoption, while high costs and lack of supportive policies hindered progress. These results emphasize that successful CSA adoption requires policy alignment, capacity building, and financial support. Ayodele etal (2020) studied the determinants of the adoption of climate-smart agricultural practices by small-scale farming households in King Cetshwayo District Municipality, South Africa. The study found that education, farm income, farming experience, land size, extension contact, media exposure, and agricultural association membership all positively influenced CSA adoption, while distance to farms and off-farm income negatively affected adoption. These findings show the central role of knowledge access, networks, and socio-economic capacity in shaping adoption.

Harad (2021) evaluated the determinants of climate-smart agricultural technology adoption in the Northern Province of Zambia. The study found that climatic pressures such as droughts, pests, and erratic rainfall were key motivators for CSA adoption, while limited access to financial resources and extension services constrained uptake. This indicates that farmers are willing to adopt CSA out of necessity, but lack adequate institutional and economic support. Getachew (2022) also analysed the determinants of adoption of climate-smart agricultural technologies and practices in the coffee-based farming system of Ethiopia. The study found that adoption rates for practices such as manure application, minimum tillage, and soil and water conservation ranged between 35–47%, and were positively influenced by education, extension access, and radio ownership. The study also found that household participation in field days encouraged CSA uptake. These results highlight the importance of communication and field-based learning in Ethiopian smallholder systems.

Feyisa (2024) studied the climate-smart agricultural practices and their implication in Ethiopia: A systematic review. The study found that demographic factors (education, family size, age), institutional support (extension, credit), and environmental conditions (topography, weather patterns) all shaped CSA adoption. The study also found that CSA adopters enjoyed better food security and resilience to shocks. This suggests that CSA not only improves productivity but also strengthens household resilience when multi-factor adoption drivers are addressed. Yohannes (2024) analysed the gender equality and sustainable development, a cross-country study on women's contribution to the adoption of climate-smart agriculture in Sub-Saharan Africa. The study found that women's role in CSA adoption varied across Ethiopia, Malawi, South Africa, and Tanzania, with women in Malawi positively influencing adoption through farm decision-making, while in other countries their limited control constrained uptake. These findings show that women's empowerment in farm decision-making is key to enhancing CSA adoption outcomes across the region.

Chileshe et al. (2023) analysed the impact of CSA practices in Eastern and Southern provinces of Zambia. The study focused on conservation agriculture, agroforestry, and use of organic fertilizers. The findings of the study indicated that households that practiced CSA had more stable food supplies and higher resilience to dry spells. However, the study also noted that the implementation was patchy and heavily reliant on donor support. Farmers in non-supported areas were often unaware of CSA techniques and lacked the capacity to implement them. The study recommended government-led farmer training programs and integration of CSA into the Farmer Input Support Programme (FISP). Zulu and Nyirenda (2022) investigated CSA awareness and implementation in Central Province. The study found that although awareness of CSA was relatively high due to NGO campaigns, actual adoption was low. The study found that farmers faced challenges such as high costs of inputs, lack of localised climate data, and poor access to extension services. The study stressed the need for district-level agricultural officers to be trained in CSA so they could effectively support local farmers.

Musonda et al (2021) conducted a study on the Copperbelt Province and found that small-scale farmers supported by NGOs such as SNV and World Vision adopted CSA techniques such as crop rotation, cover cropping, and zero tillage. These practices led to improved soil quality and yield consistency even during low-rainfall seasons. However, the study showed sustainability concerns as adoption dropped when project funding ended. The findings highlighted the need for government involvement and farmer cooperatives to take over where donor programs phase out. Muleya and Phiri (2020) explored farmers' perceptions of CSA in Southern province of Zambia. The study reported that while many farmers appreciated the benefits of CSA, few had access to tools and knowledge necessary for sustained implementation. Furthermore, the study revealed that most training sessions were conducted in English, limiting understanding among local farmers. The study recommended incorporating local languages into extension services and expanding radio-based agricultural programs to increase CSA adoption. Tembo and Chisanga (2021) evaluated the long-term effectiveness of CSA pilot projects supported by the International Fund for Agricultural Development (IFAD) and the Zambian Ministry of Agriculture. The findings of the study showed that areas where CSA was piloted experienced fewer crop failures during extreme weather events. However, farmers expressed concerns about project termination and lack of follow-up. The study recommended for institutional ownership of CSA initiatives and the development of district-level CSA task forces.

A study conducted by Ngwira (2023) assessed the impact of climate-smart agricultural interventions on crop productivity in Eastern Province. The findings of the study showed that adoption led to a twenty point two percent increase in overall crop yields and a twenty-one point five percent increase in maize yields. The study recommended continued technical and financial support for farmers, refresher training, and strengthening the agricultural extension system. This research demonstrates the tangible benefits of climate-smart agricultural practices in improving productivity and highlights the need for sustained support mechanisms to maintain adoption rates. Mulenga and Daka (2023) examined the challenges and prospects of climate-smart agricultural adoption in Zambia, identifying key barriers such as limited access to credit, inadequate policy support, and land tenure issues. The study noted that farmers more affected by climate shocks were more likely to adopt these practices. It emphasized that addressing structural and institutional challenges is essential for scaling adoption and for creating an enabling environment for sustainable agricultural practices. Kunda and Phiri (2023) also explored the application of artificial intelligence tools to enhance the resilience of smallholder farmers to climate variability. The study highlighted how artificial intelligence-powered weather forecasting and decision-support systems can empower farmers to make informed planting and resource management decisions. This study underscored the potential of technological innovations in improving adoption, enabling farmers to respond proactively to climate challenges.

### Identified Research Gap and its Justification

From the reviewed Global, African, and Zambian literature, it is evident that Climate-Smart Agriculture (CSA) has been widely recognized as an effective approach for improving resilience among small-scale farmers. Numerous studies have demonstrated the positive impacts of CSA practices such as conservation agriculture, agroforestry, improved irrigation, and drought-resistant crop varieties in enhancing food security, soil health, and adaptive capacity to climate variability (Smith et al., 2022; Mwongera et al., 2021; Chileshe et al., 2023). These studies also acknowledge key implementation challenges including limited extension support, poor institutional coordination, financial constraints, and low farmer participation, especially in Africa and Zambia (Zulu and Nyirenda, 2022; Musonda et al., 2021; Dinesh et al., 2020). However, a critical gap exists in the context-specific evaluation of CSA implementation at the local or district level in Zambia. While national and provincial-level studies (Chileshe et al., 2023; Tembo and Chisanga, 2021) provide valuable insights, the studies often generalize findings without capturing the unique socio-economic, institutional, and environmental conditions of individual districts or camps. Specifically, Chibombo district despite being a key agricultural hub in Central Province has received limited empirical attention in existing CSA literature. The reviewed studies have not adequately examined how CSA interventions are being implemented, monitored, or adopted within Chibombo agriculture camps, nor how these practices are impacting the resilience of local small-scale farmers.

### Research Methodology

The study employed the mixed research approach to collect and analyse the data. The study will employ the embedded research design. The target populations of the study were small scale farmers, Agriculture Camp Officer, Agriculture Block Officer of Mwachisompola Agricultural Camp, Senior Agriculture Officer and District Agriculture Officer of Chibombo district. The sample size was two hundred fifty four (254). These included one (1) Agriculture Camp Officer, one (1) Block Agricultural Officer, one (1) District Agriculture Officer and One (1) Senior Agriculture Officer and two hundred fifty (250) small scale farmers from the selected Mwachisompola agriculture camp of Chibombo district. Simple random sampling was used to select the two hundred fifty (250) small scale farmers while purposive sampling was used to select one (1) Agriculture Camp Officer, one (1) Block Agricultural Officer, one (1) District Agriculture Officer and One (1) Senior Agriculture Officer. The research instruments used collect data were questionnaire and the interview guide. The methods used to collect data were survey and interviews. Thematic analysis was used to analyse qualitative data while descriptive statistical analysis with the use of the mean and standard deviation was used to analyse the quantitative data.

## RESEARCH FINDINGS

### Adoption of Climate-Smart Agriculture Practices

The data from Table1 shows an overall weighted mean of 3.44, which falls within the Agree category (3.41–4.20). This indicates that, on average, respondents tend to practice climate-smart agriculture, although the level of adoption is moderate rather than very high or widespread. An examination of the mean scores reveals that practices such as crop diversification (M = 3.88), application of organic fertilizers (M = 3.64), and use of drought-tolerant crop varieties (M = 3.56) have relatively higher mean values, suggesting that farmers are more inclined to adopt agronomic and soil management strategies that are accessible and less resource-intensive. In contrast, practices such as rainwater harvesting (M = 3.04) and improved irrigation techniques (M = 3.08) have lower mean scores, falling within the neutral range, which indicates limited or inconsistent adoption as shown in Table 1.

Table 1: Adoption of climate-smart agricultural practices

| **Statement** | **SD f (%)** | **D f (%)** | **N f (%)** | **A f (%)** | **SA f (%)** | **Mean** | **σ** | **Decision** |
|---|---|---|---|---|---|---|---|---|
| Drought-tolerant crops | 20 (8.0%) | 30 (12.0%) | 50 (20.0%) | 90 (36.0%) | 60 (24.0%) | 3.56 | 1.20 | Agree |
| Conservation agriculture | 25 (10.0%) | 35 (14.0%) | 60 (24.0%) | 80 (32.0%) | 50 (20.0%) | 3.38 | 1.23 | Agree |
| Organic fertilizers | 15 (6.0%) | 25 (10.0%) | 55 (22.0%) | 95 (38.0%) | 60 (24.0%) | 3.64 | 1.12 | Agree |
| Crop diversification | 10 (4.0%) | 20 (8.0%) | 40 (16.0%) | 100 (40.0%) | 80 (32.0%) | 3.88 | 1.05 | Agree |
| Rainwater harvesting | 40 (16.0%) | 50 (20.0%) | 60 (24.0%) | 60 (24.0%) | 40 (16.0%) | 3.04 | 1.30 | Neutral |
| Improved irrigation | 35 (14.0%) | 45 (18.0%) | 70 (28.0%) | 65 (26.0%) | 35 (14.0%) | 3.08 | 1.25 | Neutral |
| Climate information access | 20 (8.0%) | 30 (12.0%) | 60 (24.0%) | 85 (34.0%) | 55 (22.0%) | 3.50 | 1.18 | Agree |

Source: Field Work, 2026 N = 250

Key: σ = Standard Deviation Decision (Weighted average) $\frac{24.08}{7} = 3.44$

The data shows that farmers tend to adopt climate-smart agricultural practices that are more accessible, affordable, and easier to implement, such as drought-tolerant crops, organic fertilizers, crop diversification, and the use of climate information, indicating a strong preference for low-cost and knowledge-based strategies that enhance resilience and reduce risk. Conservation agriculture is adopted to a moderate extent, suggesting that while farmers recognize its benefits for sustainable land management, its implementation may be constrained by the need for additional skills, labor, or consistent application. In contrast, practices related to water management, including rainwater harvesting and improved irrigation have low adoption levels, reflecting challenges such as high costs, limited infrastructure, and insufficient technical support, which hinder farmers' ability to invest in and sustain these resource-intensive interventions as shown in Table 2.

Table 2: Adoption of climate-smart agricultural practices

| **Major Theme** | **Subtheme** |
|---|---|
| Widely Adopted Climate-Smart Practices | Drought-tolerant crops |
| | Organic fertilizers |
| | Crop diversification |
| | Climate information access |
| Moderately Adopted Sustainable Land Management Practices | Conservation agriculture |
| Low Adoption of Water Management Practices | Rainwater harvesting |
| | Improved irrigation |

Source: Field Work, 2026

**Widely Adopted Climate-Smart Practices**

**Drought-tolerant crops**

P1said that:

> I have switched most of my fields to drought-tolerant crops because the weather has become unpredictable. In the past, dry seasons would destroy my harvest, leaving my family with food shortages and financial problems. Now, even with irregular rainfall, I always have some harvest, which gives me stability.

P2 explained that:

> Using drought-resistant seeds has reduced crop losses and allows me to plan my planting schedule better. The crops survive dry spells, so I don't have to worry about losing everything.

P3 discussed that:

> Drought-tolerant crops survive much better than traditional ones and give me a reliable source of food even when rainfall is low. I can feed my family and sell some of the surplus at the market.

P4 discussed that:

> Planting drought-tolerant crops ensures food security for my household and allows me to sell some extra produce. This has improved both our food supply and income.

**Organic fertilizers**

P1 indicated that:

> I rely mostly on manure from my livestock because it naturally improves the soil and reduces my need for expensive chemical fertilizers. The crops grow healthier and better with organic fertilizer.

P2 revealed that:

> Using compost and animal manure has improved crop growth and soil fertility. I make the fertilizer from farm resources, which save money and are environmentally friendly.

P3 shared that:

> Switching from chemical to organic fertilizers has made my crops healthier and more productive. The soil remains fertile for longer periods, so it's a sustainable way to farm.

P4 said that:

> Organic fertilizers are cheap, easy to find, and simple to use. My crops grow well, and the yields have increased, so I continue using this method.

**Crop diversification**

P1 reported that:

> I grow several crops like maize, beans, and groundnuts together to reduce the risk of losing everything. If one fails, the others provide food and some to sell.

P2 revealed that:

> Growing different crops helps me manage farming risks. Even in a bad season, I still get some harvest to feed my family and sell.

P3 explained that:

> Planting multiple crops together protects me from unpredictable weather and pests. There is always something to harvest, so I feel more secure.

P4 indicated that:

> Mixing crops improves soil fertility and reduces dependence on a single crop. I can feed my family and sell surplus produce, which helps with income.

**Climate information access**

P1 said that:

> I listen to weather forecasts on the radio to know when to plant. This prevents me from losing crops due to unexpected rainfall or dry spells.

P2 reported that:

> Extension officers give advice on upcoming rains. I prepare my fields according to this information, which helps my crops grow better.

P3 said that:

> I follow climate updates and adjust planting and harvesting schedules according to the expected rainfall. This reduces risk and improves my harvest.

P4 indicated that:

> Access to climate information helps me choose crops, plan irrigation, and manage my farm activities. It makes farming less uncertain.

**Moderately Adopted Sustainable Land Management Practices**

**Conservation agriculture**

P1 shared that:

> I practice minimum tillage and leave crop residues on the field, but it is hard work and not easy to maintain every season.

P2 lamented that:

> Conservation agriculture improves soil fertility, but not everyone in my community can do it properly. Some people lack resources or knowledge.

P3 discussed that:

> I rotate crops and leave residues, but sometimes I go back to traditional farming because it is less labor-intensive.

P4 shared that:

> Techniques like planting basins or leaving residues are difficult to do without guidance. I try to do them, but it is hard to be consistent.

**Low Adoption of Water Management Practices**

**Rainwater harvesting**

P1 said that:

> I cannot practice rainwater harvesting because I don't have tanks or gutters. The cost of setting it up is too high.

P2 indicated that:

> I don't know how to store rainwater properly, so I just rely on rainfall, even though it is unreliable.

P3 reported that:

> Materials and labor to build a rainwater system are too expensive. I know it is useful, but I cannot afford it.

P4 added that:

> There is no technical support or tools to help me harvest rainwater effectively, so I haven't been able to adopt it.

**Improved irrigation**

P1 said that:

> I depend completely on rainfall because irrigation systems are too expensive to buy and maintain.

P2 shared that:

> I have seen my neighbors use irrigation and benefit from it, but I cannot afford pumps, pipes, or tanks.

P3 indicated that:

> Water sources near my farm are limited, so even if I had the equipment, I could not use it consistently.

P4 said that:

> I know irrigation could increase my production, but I don't have the money or infrastructure to implement it

## DISCUSSION OF RESEARCH FINDINGS

### Adoption of Climate-Smart Agriculture Practices

The study sought to determine the extent to which smallholder farmers in Mwachisompola Agricultural Camp have adopted Climate-Smart Agriculture (CSA) practices. The study findings revealed that the level of adoption is generally moderate, with variations across different types of practices. Farmers tend to widely adopt practices that are affordable, accessible, and provide immediate benefits, such as drought-tolerant crops, organic fertilizers, crop diversification, and the use of climate information, as these directly improve yields, enhance food security, and reduce vulnerability to climate variability. In contrast, practices that require higher financial investment, technical expertise, or infrastructural support such as improved irrigation and rainwater harvesting show lower levels of adoption. The findings further indicated that adoption decisions are largely influenced by the perceived relative advantage, cost, labor requirements, and complexity of the practices.

### Widely Adopted Climate-Smart Practices

### Drought-tolerant Crops

The findings of the study showed that drought-tolerant crops are widely adopted because they improve crop yields, enhance food security, and reduce the risks associated with erratic rainfall. Farmers indicated that these crops provide more reliable harvests even under harsh climatic conditions, making them a preferred adaptation strategy. The ability of these crops to withstand dry spells and unpredictable weather conditions ensures that farmers can secure at least a minimum level of production, which is critical for sustaining household livelihoods. This suggests that farmers are more inclined to adopt practices that directly address climate-related challenges and provide immediate, tangible benefits, particularly in environments where climate variability poses a constant threat to agricultural productivity.

The study findings were in consistent with Everett Rogers (2003) diffusion innovations theory with a clear relative advantage are more likely to be adopted rapidly. In the context of this study, drought-tolerant crops demonstrate a strong relative advantage by offering improved yields and reduced vulnerability to climate shocks. Similarly, Abegunde et al. (2024), in a study conducted in Nigeria, found that drought-tolerant crop varieties significantly improved farm productivity and resilience among smallholder farmers, leading to higher adoption rates. This supports the current study, as both findings highlight that farmers prioritize technologies that enhance productivity and reduce risk. However, while Abegunde et al. (2024) primarily emphasized productivity gains as the key driver of adoption, the current study further reveals that food security and the stability of household livelihoods are equally important motivating factors influencing farmers' decisions.

Furthermore, Mutenje et al. (2025), in a study conducted in Malawi, found that access to improved seed varieties and extension services significantly influenced the adoption of drought-tolerant crops. This finding aligns with the current study, which also shows that institutional support plays a crucial role in facilitating adoption by improving farmers' knowledge and access to inputs. Extension services, in particular, help farmers understand how to effectively use improved seed varieties and adapt to changing climatic conditions. However, the present study adds that even when farmers recognize the benefits of drought-tolerant crops, limited access to inputs such as quality seeds can still constrain widespread adoption. This highlights the importance of strengthening input distribution systems and institutional support to ensure that more farmers can benefit from these climate-smart technologies.

### Organic Fertilizers

The study findings indicated that organic fertilizers are widely adopted due to their affordability, accessibility, and ability to improve soil fertility. The study revealed that relying on locally available resources such as manure and compost, which reduce dependence on expensive chemical fertilizers while enhancing soil productivity. The use of these inputs allows farmers to maintain soil health in a sustainable manner without incurring high production costs. This suggests that cost-effectiveness and ease of access are key drivers of adoption among smallholder farmers, particularly in resource-constrained settings where financial limitations influence decision-making. The study finding was in line with Everett Rogers (2003), who explained that innovations that are compatible with existing practices and require low complexity are more likely to be adopted. Organic fertilizers fit well within traditional farming systems, as farmers are already familiar with the use of livestock manure and composting methods. Similarly, Ndamani and Watanabe (2024) found that farmers prefer organic soil management practices because they are low-cost, environmentally sustainable, and easy to integrate into existing farming systems. This supports the study finding, as both emphasized that affordability, sustainability, and compatibility play a significant role in influencing adoption decisions among smallholder farmers.

However, while Ndamani and Watanabe (2024) found that organic fertilizers and labor constraints as a key limitation affecting their sustained use. The preparation, transportation, and application of organic fertilizers require considerable time and effort, which may be challenging for households with limited labor availability. In support of this, Moyo et al. (2025) found that the labor-intensive nature of organic fertilizer preparation can hinder its widespread use, particularly among smallholder farmers with limited household labor. Although the current study shows high levels of adoption, this evidence suggests that labor demands may influence the extent to which farmers can consistently and sustainably apply organic fertilizers over time.

### Crop Diversification

The study findings showed that crop diversification is widely adopted as a strategy to manage risk and improve resilience among smallholder farmers. Farmers reported that growing multiple crops ensures that they still obtain yields even when one crop fails, thereby reducing the likelihood of total crop loss. This practice enhances both food security and income stability, as farmers can rely on alternative crops for consumption and sale. The results indicate that diversification is a practical and reliable strategy for coping with climate variability, particularly in environments characterized by unpredictable weather patterns. These findings support Everett Rogers (2003) theory that innovations that are compatible with existing practices are more easily adopted. Crop diversification aligns well with traditional mixed farming systems, making it easier for farmers to integrate into their current practices without requiring significant changes. Similarly, Teklewold et al. (2024), in a study conducted in Ethiopia, found that crop diversification significantly improves resilience and reduces vulnerability among smallholder farmers. This is consistent with the current study, as both highlighted diversification as an effective adaptation strategy that helps farmers cope with climate-related risks.

However, while Teklewold et al. (2024) emphasized resilience outcomes, the present study further shows that crop diversification also contributes to income generation and improved household food security. Farmers not only use diversification as a risk management strategy but also as a means of enhancing their livelihoods. Kassie et al. (2025) also found that access to markets and agricultural inputs plays a critical role in determining the success of diversified farming systems. This complemented this study that although adoption is high, external factors such as market access, input availability, and institutional support are essential for maximizing the benefits of crop diversification. The study findings further revealed that access to climate information is a critical factor in enabling farmers to make informed decisions regarding their agricultural activities. These results are consistent with Everett Rogers (2003) theory that communication channels are essential in the diffusion of innovations. Innovations are more likely to be adopted when potential adopters receive adequate information about their benefits and usage. Ayanlade et al. (2024) also found that access to climate information significantly enhances farmers' adaptive capacity and increases the likelihood of adopting climate-smart agricultural (CSA) practices. Both studies align with the current study, highlighting that access to information directly influences farmers' decisions to adopt innovative practices. However, while Ayanlade et al. (2024) primarily focused on the benefits of information access, the present study further highlights challenges related to reliability, consistency, and accessibility of climate data. Farmers reported difficulties in accessing accurate forecasts or advisory services consistently, which can limit the effectiveness of climate information in guiding farming decisions. Dinku et al. (2025) similarly found that limited access to timely and accurate climate information can hinder effective decision-making and constrain adaptation efforts. This aligns with the study findings, reinforcing the need for improved dissemination systems and extension support to ensure that farmers can fully benefit from climate information in adopting CSA practices.

## Adopted Sustainable Land Management Practices

### Conservation Agriculture

The study findings indicated that conservation agriculture is moderately adopted because farmers recognize its benefits for soil fertility and sustainability but face implementation challenges. Farmers reported using practices such as minimum tillage, residue retention, and crop rotation, yet they struggle to apply them consistently due to labor requirements and effort intensity. This pattern reflects a partial integration of conservation agriculture, where farmers understand the theoretical benefits but find it difficult to sustain the practices over time. Similar patterns have been observed in recent research, where farmers adopted conservation agriculture only partially because the labor demands were high and benefits were less immediate (Ngoma & Chirwa, 2024; Mahmud et al., 2025). These studies support the study finding that farmers are aware of the value of sustainable land management but encounter barriers that reduce full adoption.

Thierfelder et al. (2024) found that adoption of conservation agriculture was constrained by labor requirements and the technical knowledge needed to implement practices effectively, reinforcing the present study's results. Makombe and Banda (2025) observed that many smallholder farmers in Malawi lacked the skills or training to consistently implement residue retention and minimum tillage, further confirming that the complexity of conservation agriculture slows its adoption without strong support measures. However, while these studies emphasized labor and knowledge constraints, the present study also highlights inconsistency in farmers' ability to maintain these practices as a distinct challenge. The study noted that even when they attempt conservation techniques, they sometimes revert to traditional methods because of short-term workload pressures or lack of on-going guidance. Brown et al. (2025) found that access to extension services significantly influences the adoption of conservation agriculture, showing that when farmers receive regular technical support, they adopt and maintain practices more consistently. The study by Adu and Boateng (2024) also revealed that enhanced institutional support and farmer training were key factors in improving uptake and consistency of conservation agriculture in Ghana. These findings suggested that strengthening extension support and continual capacity building are essential for moving conservation agriculture from moderate to widespread adoption.

## Low Adoption of Water Management Practices

### Rainwater Harvesting

The study findings showed that rainwater harvesting has low adoption among smallholder farmers primarily due to high costs, lack of infrastructure, and limited technical knowledge. Farmers reported that setting up tanks, gutters, or storage facilities requires significant financial investment, which is beyond their means given existing resource constraints. This financial burden discourages many from implementing rainwater harvesting even when they recognize its potential benefits for water security during dry periods. The study findings echoed this pattern, with studies conducted in Tanzania highlighting that high setup and maintenance costs deter many smallholders from adopting rainwater harvesting systems (Katambo & Mdoe, 2024; Sanga & Lema, 2025). These studies reinforce the present findings by showing that cost remains a central constraint to uptake, where traditional water access depends on rainfall. Similarly, Mwangi et al. (2024), in a study conducted in Kenya, found that financial limitations and technical constraints significantly limit the adoption of water harvesting technologies among smallholder farmers. The study underscored that without affordable financing options and accessible technical assistance, water harvesting remains an unattainable strategy for many. Both this study and the study by Mwangi et al. (2024) highlighted that cost and complexity jointly act as barriers, slowing the diffusion of rainwater harvesting technologies.

Moreover, while Mwangi et al. (2024) focused predominantly on financial barriers, the present study also highlights the lack of technical support as a key constraint inhibiting adoption. Farmers expressed that even when they are willing, they lack the necessary knowledge and guidance to design, construct, and maintain effective rainwater systems. Supporting this, Nhemachena et al. (2025) found that access to training and extension services is essential for adopting water management practices, including rainwater harvesting, because these services build farmers' confidence and technical capacity. Similarly, Zulu and Phiri (2025) noted that where extension support is weak or absent, adoption of water technologies remains low despite awareness of benefits. Together, these findings suggest that improving technical support and expanding extension outreach are critical for enhancing the adoption of rainwater harvesting among smallholder farmers.

### Improved Irrigation

The study findings indicated that improved irrigation practices have low adoption among smallholder farmers due to a combination of financial, infrastructural, and environmental constraints. The study reported that modern irrigation systems, such as pump-driven sprinklers or drip lines, involve significant upfront costs for equipment, fuel, and maintenance that are beyond their financial capacity. In addition, the absence of reliable water sources such as boreholes, rivers, or dams limits their ability to use such systems even when the equipment is available. This suggests that, for many farmers, the concept of irrigation remains theoretically beneficial but practically unattainable under existing resource limitations and environmental conditions. In support of this, Xie et al. (2024), in a study conducted across Sub-Saharan Africa, found that the high cost of irrigation equipment and the lack of affordable financing options significantly limit its adoption among smallholder farmers. Their research highlights that financial barrier including the inability to purchase or maintain irrigation systems are major determinants of slow uptake. These findings reinforce the current study's conclusion that economic constraints are central to the low adoption of improved irrigation. However, while Xie et al. (2024) emphasized the role of financial constraints, the present study also highlights environmental limitations such as water availability as equally critical factors. Farmers noted that even if irrigation systems were affordable, the absence of consistent water sources would render them ineffective, revealing an environmental dimension to the adoption barrier. This perspective is supported by Burney et al. (2025), who found that access to infrastructure and dependable water resources is critical for the successful adoption of irrigation technologies in smallholder contexts. Their study shows that without investments in water storage, distribution networks, or community water projects, irrigation interventions are unlikely to succeed. Together, these findings suggest that improving adoption of improved irrigation requires not only addressing economic limitations but also investing in water infrastructure and sustainable resource management to create an enabling environment for such technologies.

## CONCLUSION

The adoption of Climate-Smart Agriculture (CSA) practices among smallholder farmers in Mwachisompola Agricultural Camp is moderate and varies across different types of practices. Farmers tend to adopt practices that are affordable, accessible, and provide immediate and visible benefits, particularly those that enhance productivity, improve food security, and reduce vulnerability to climate variability. In contrast, practices that require substantial financial investment, technical expertise, or infrastructural support are less commonly adopted. Adoption is largely influenced by the perceived benefits, cost, labor requirements, and complexity of the practices. This implies that interventions aimed at scaling up CSA should prioritize promoting low-cost, easily adoptable practices while simultaneously addressing barriers associated with more complex technologies through subsidies, training, and infrastructure development.

### Recommendations

i. The Government of the Republic of Zambia, through the Ministry of Agriculture, should strengthen agricultural extension services by recruiting and deploying more extension officers in rural farming communities, providing continuous professional development for extension personnel, and promoting regular farmer field schools, demonstrations and climate-smart agriculture (CSA) training programmes. Strengthened extension services mighty improve farmers' access to technical knowledge, enhance the adoption of CSA technologies, and increase resilience to climate change.
ii. The Government of the Republic of Zambia, through the Ministry of Agriculture, should implement targeted financial support mechanisms such as input subsidies, low-interest agricultural loans and grant schemes that enable smallholder farmers to access improved seed varieties, irrigation technologies, conservation agriculture equipment, and other climate-smart innovations. These interventions mighty reduce financial barriers to CSA adoption.

iii. The Government of the Republic of Zambia, through the Ministry of Agriculture and relevant stakeholders, should invest in rural agricultural infrastructure and climate information services. This should include expanding irrigation facilities, improving feeder roads and market access, strengthening water harvesting systems, and enhancing the timely dissemination of localized weather and climate forecasts through extension officers, community radio, and digital platforms. Such investments might improve farmers' adaptive capacity and support sustainable agricultural productivity.

**Recommendations for Future Research**

i. An Evaluation of the Long-Term Effects of Climate-Smart Agriculture on Smallholder Farmers' Productivity in Zambia.
ii. An Exploration of the Socio-Economic and Gender Factors Influencing the Adoption of Climate-Smart Agriculture among Smallholder Farmers in Zambia.
iii. An Assessment of the Effectiveness of Subsidies in Promoting Climate-Smart Agriculture Adoption in Zambia.
iv. An Investigation of the Institutional and Policy Support in Enhancing Sustained Adoption of Climate-Smart Agriculture Practices among Smallholder Farmers in Zambia.

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